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Short-rotation forestry of birch, maple, poplar and willow in Flanders (Belgium) II. Energy production and CO_2 emission reduction potential

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Abstract

Belgium, being an EU country, has committed itself to a 7.5% reduction of greenhouse gas emissions during the first commitment period of the Kyoto Protocol. Within this framework, the Flemish government aims at reaching a share of 6% of renewable electricity in the total electricity production by 2010. In this work, the biomass production of birch, maple, poplar and willow in a short-rotation forestry (SRF) plantation after a 4-year growth period served as the base to calculate the amount of (electrical) energy that could be produced by this type of bioenergy crop in Flanders. The maximum amount of electricity that could be provided by SRF biomass was estimated at 72.9 $GWh_e\,year^{-1}$, which only accounts for 0.16% of the total electricity production in this region. Although the energy output was rather low, the bioenergy production process under consideration appeared to be more energy efficient than energy production processes based on fossil fuels. The high efficiency of birch compared to the other species was mainly due to the high calorific value of the birch wood. The maximum CO_2 emission reduction potential of SRF plantations in Flanders was estimated at only 0.09% of the total annual CO_2 emission. The most interesting application of SRF in Flanders seemed to be the establishment of small-scale plantations, linked to a local combined heat and power plant. These plantations could be established on marginal arable soils or on polluted sites, and they could be of importance in the densely populated area of Flanders because of other environmental benefits, among which their function as (temporary) habitat for many species.

Keywords: Bioenergy; Birch; CO_2 emission reduction; Energy efficiency; Maple; Poplar; Short-rotation forestry; Willow

1. Introduction

The European Kyoto target is an 8% reduction in annual greenhouse gas emissions by the first commitment period (2008–2012), compared to the reference year 1990 [1]. In this context, the European Commission set the target to increase renewable energy sources to reach 12% of the European gross energy consumption by 2010 [2]. Short-rotation plantations can be expected to play a major role in the production of biomass for bioenergy. Biomass produced in short-rotation plantations can serve as a substitute for fossil fuels, reducing as such the emission of greenhouse gases to the atmosphere and helping to attain the greenhouse gas emission reduction target [2–6]. Moreover, short-rotation plantations are one of the measures indicated by the Art. 3.4 (additional activities) of the Kyoto Protocol [1,7], which can lead to a significant uptake of carbon from the atmosphere.

Belgium, being an EU country, has committed itself to a 7.5% reduction of greenhouse gas emissions during the first commitment period of the Kyoto Protocol. Within this framework, the government of the Flemish region aims at reaching a share of 6% of renewable electricity in the total electricity production by 2010. To reach this objective, the Flemish energy market has been fully opened for external competition. Therefore, a green certificate system for

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electricity has been established, and a similar system for 'green heat' production is under development actually. In this way, the Flemish government hopes to stimulate the use of biomass as an energy source [8,9].

In the present study, the potential use of biomass from short-rotation forestry (SRF) in Flanders is evaluated. Actually, only a few hectares of experimental plantations exist in Belgium [10]. One of these plantations was established on former agricultural land in 2001, and the growth of four tree species (birch, maple, poplar and willow) was studied there. Based on biomass production results of this plantation [11], the possible contribution of SRF plantations to the total electricity production in Flanders was determined. Furthermore, the potential of SRF plantations to reduce the CO_2 emissions in this region was assessed, within the overall scope of achieving the Kyoto Protocol targets.

2. Materials and methods

2.1. Short-rotation plantation

In March and April 2001, a short-rotation plantation was established on former agricultural land. The site is situated at Zwijnaarde (51°02′ N, 3°43′ E), 10 km south of the centre of Ghent (Belgium). In total, 22 plots of 400 m^2 each (25 m × 16 m) were planted. Birch (*Betula pendula* Roth), maple (*Acer pseudoplatanus* L.—Tintigny), poplar (*Populus trichocarpa × deltoides*—Hoogvorst) and willow (*Salix viminalis*—Orm) were planted on four, three, eight and seven plots, respectively. An extensive description of soil characteristics, plant material, planting scheme and management activities can be found in a joint paper [11].

2.2. Aboveground biomass production

In January 2005, the potential biomass production $PROD_{pot}$ (t DM ha^{-1} $year^{-1}$) of the 21 plots was determined. The methodology applied to calculate $PROD_{pot}$ is given by Vande Walle et al. [11]. In Table 1, a summary of the mean annual production results after 4 years of tree growth is given. In this table, both the mean biomass production and the maximum result are presented for each species.

Table 1
Number of plots (#), mean (with standard error), maximum potential biomass production $PROD_{pot}$ (t DM ha^{-1} $year^{-1}$) and coefficient of variation (CV) (%) of birch, maple, poplar and willow after 4 years of tree growth at the short-rotation plantation in Zwijnaarde

Species	#	$PROD_{pot}$ (t DM ha^{-1} $year^{-1}$)		CV (%)
		Mean (s.e.)	Max.	
Birch	4	3.3 (0.4)	4.4	29.2
Maple	3	1.2 (0.3)	1.7	45.0
Poplar	8	4.2 (0.3)	5.4	20.2
Willow	6	3.5 (0.6)	5.9	44.2

2.3. Calorific value of the wood

The calorific value of wood (*CAL*, kJ g^{-1} DM) indicates its energy content. It represents the amount of energy liberated when the wood is burned [12]. Four trees, with a mean diameter, per species were cut in December 2003 in order to determine the calorific value. Wood samples were taken all over the stem for this purpose. Samples of stem and branch wood were dried at 40 °C until constant weight, and subsequently ground on a 1 mm sieve. After drying again for 24 h, the calorific value of the samples was experimentally determined with an oxygen bomb calorimeter (model IKA C7000). The calorific value of stem wood and branch wood was determined separately, and a mean value for the whole tree was calculated based on the relative dry mass contribution of branches and stems. The bark was not removed, since this is mostly no option in commercial SRF plantations.

2.4. Energy production

The energy stored in woody biomass can be transformed into 'usable' energy. Usable energy is energy in a form that is sold (electricity, heat, etc.). In policy documents, reference is made to this usable energy [2]. Before transformation can take place, the wood has to be dried to improve the conversion efficiency. Two drying procedures are used in practice. The first option is to transport the harvested wood immediately to a special location or building where the drying process takes place under controlled conditions. The second option is the on-site storage and drying of harvested stems. In this study, the second option was chosen, as the energy input needed for this drying procedure is much lower than for off-site drying. However, drying under field conditions results in a small decrease of biomass (4% for willow and 13% for poplar) [13,14]. For birch and maple, a biomass decrease of 2% was assumed by field drying, as the moisture content of these two species (birch: 45.7% and maple: 45.3%) was lower than for willow (50.3%) and poplar (54.2%) [15].

The energy stored in the biomass, EN_{DM}, was calculated using

$$EN_{DM} = \alpha \, PROD_{pot} \, CAL, \tag{1}$$

where EN_{DM} is the energy stored in the biomass after 4 years of tree growth (GJ ha^{-1} $year^{-1}$), α the correction factor for the loss of biomass due to drying (α equals 0.98 for birch and maple, 0.87 for poplar and 0.96 for willow), $PROD_{pot}$ the potential biomass production after 4 years of tree growth (t DM ha^{-1} $year^{-1}$) and *CAL* the calorific value of the wood (kJ g^{-1} DM).

In this study, three types of conversion processes were considered, which can be used to transform the biomass energy EN_{DM} into usable energy: co-burning, burning and gasification. Conversion efficiencies (*CE*) of these three processes were given by García Cidad et al. [16], and are presented in Table 2. Both efficiencies for converting the

Table 2
Conversion efficiencies ($GJ\,GJ^{-1}$) of co-burning, burning and gasification processes applied to transform biomass energy into electricity (CE_e) or heat (CE_{th}) [29]

Conversion technique	CE_e	CE_{th}
Co-burning	0.37	0.50
Burning	0.16	0.69
Gasification	0.27	0.53

biomass energy into electricity (CE_e) and heat (CE_{th}) are given. The electrical energy that can be produced from the biomass of a specific species, EN_e ($GJ\,ha^{-1}\,year^{-1}$), was calculated by

$$EN_e = CE_e\,EN_{DM} \tag{2}$$

and the thermal energy, EN_{th} ($GJ\,ha^{-1}\,year^{-1}$) by

$$EN_{th} = CE_{th}\,EN_{DM}. \tag{3}$$

2.5. Energy efficiency

When bioenergy production systems are compared, not only the biomass production, expressed as $t\ DM\,ha^{-1}\,year^{-1}$, but also the energy efficiency (EE) of the systems is an important characteristic. The energy efficiency, EE, expresses the number of energy units produced by the system per unit of energy input needed to drive the system [3,5,16,17]:

$$EE = \frac{EN_{output}}{EN_{input}}, \tag{4}$$

where EE is the energy efficiency of the energy production process (dimensionless), EN_{output} the usable energy produced ($GJ\,ha^{-1}\,year^{-1}$) and EN_{input} the energy input needed to produce and transport biomass, and to convert biomass into usable energy ($GJ\,ha^{-1}\,year^{-1}$).

Energy efficiencies for fossil fuel-based energy production systems are typically lower than 1: 0.74–0.84 for petrol and 0.88 for diesel [16]. The energy output, EN_{output}, can be equal to the amount of electricity produced (EN_e), the heat production (EN_{th}) or the total energy produced ($EN_e + EN_{th}$). Here, the EN_{output} was calculated for each species based on the mean potential biomass production results.

The bioenergy production process can be subdivided in three stages where energy input is needed. This is reflected in

$$EN_{input} = EN_{est} + EN_{trans} + EN_{conv}, \tag{5}$$

where EN_{est} is the energy input needed for the establishment of the SRF plantation, including the application of herbicides and fertilizers, and the harvest of the wood ($GJ\,ha^{-1}\,year^{-1}$), EN_{trans} the energy input needed to prepare the harvested wood and to transport it to the installation where the conversion will take place ($GJ\,ha^{-1}\,year^{-1}$) and EN_{conv} the energy input needed for the conversion process ($GJ\,ha^{-1}\,year^{-1}$).

Table 3
Energy use during the establishment phase of a SRF plantation; information extracted from Sintzoff et al. [14], García Cidad et al. [16], Dalgaard et al. [17] and Hülsbergen et al. [18]

Activity	Value	Unit
(1) Direct energy use		
Ploughing and preparation of the soil	37.0	l diesel ha^{-1}
Use of machines at harvest	14.0	l diesel ha^{-1}
Chipping of the wood	13.9	l diesel t^{-1} DM
Transport of machines to the field	0.1	l diesel km^{-1}
Loading of the biomass	2.9	l diesel t^{-1} DM
Energy use due to diesel consumption	40.9	$MJ\,l^{-1}$ diesel
Energy use due to the use of lubricating oil	3.6	$MJ\,l^{-1}$ diesel
(2) Indirect energy use		
Production of machines	12.0	$MJ\,l^{-1}$ diesel
Production of plant material (cuttings or young trees)	300.0	$MJ\,ha^{-1}$

The energy input needed during the establishment phase of the plantation, EN_{est}, can on its turn be subdivided in direct and indirect energy use. In Table 3, an overview is given of energy input values used in this study. Human labour and solar energy were ignored. The assumption was made here that the plantation lasts for a period of 20 years, and that a rotation length of 4 years is applied. As was the case for the plantation in Zwijnaarde, it was assumed that no fertilizers, lime or herbicides were applied.

To calculate EN_{trans}, an energy input of $0.8\,MJ\,t^{-1}$ $DM\,km^{-1}$ for the transport of the harvested wood to the conversion installation was assumed [19]. The mean distance between a SRF plantation and a co-burning, burning or gasification installation in Flanders was estimated by García Cidad et al. [16] at 25, 22 and 12.5 km, respectively.

The energy input for the conversion process itself, EN_{conv}, was estimated at 7% of the energy stored in the woody biomass, EN_{DM}, added to a co-burning system, and 5% for a burning or gasification system [16].

2.6. CO_2 emission reduction potential

The burning of biomass from SRF plantations can be considered as a CO_2 neutral process [20], since the CO_2 liberated during the burning process will be sequestered during the next rotation period [21]. The production of energy from biomass however requires a certain input of fossil energy, emitting a corresponding quantity of carbon dioxide to the atmosphere. On the other hand, SRF biomass is only partly harvested, as the roots and stumps

remain on the site as unutilized biomass. The carbon stored in these parts slowly decomposes, and becomes incorporated into the soil organic matter (SOM). It was assumed here, in accordance to Sáez et al. [22], that the carbon input into the soil will be comparable to the amount of C released during cultivation and transport, so that the biomass fuel cycle may be considered to be carbon neutral, a statement supported by the studies of Matthews [5] and Lettens et al. [23].

When bioenergy is used as a substitute for energy produced from fossil fuels, carbon emissions to the atmosphere are reduced [24]. The CO_2 emission reduction potential of SRF plantations in Flanders was calculated using

$$ER_C = EN_e\, A\, EM_C, \tag{6}$$

where ER_C is the CO_2 emission reduction potential (kg CO_2 $year^{-1}$), EN_e the amount of electricity that can be produced from the biomass of a specific species (GJ ha^{-1} $year^{-1}$), A the total area of plantations (ha) and EM_C the amount of CO_2 emitted during a traditional electricity production process (kg CO_2 GJ^{-1}).

As in Flanders there is actually only a green certificate system for electricity, and not for thermal energy, we focused the calculations on the use of bioelectricity here. Sintzoff et al. [14] reported a CO_2 emission of 263.9 kg CO_2 GJ_e^{-1} produced in the oldest electrical coal plant in Belgium, while the emission was estimated at 136.1 kg CO_2 GJ_e^{-1} produced in the most modern gas turbine. These values are comparable to the ones mentioned by Matthews and Robertson [25]. In the Spatial Structure Plan of the regional government of Flanders, 10,000 ha are intended for the establishment of energy forests [8,26]. This number of 10,000 ha can be interpreted as the maximum area that will become available for the establishment of SRF plantations in Flanders. Here, we calculated the CO_2 emission that could be avoided by using the biomass grown on this maximal area of 10,000 ha, based on the mean potential production results of the plantation at Zwijnaarde.

3. Results

3.1. Energy content of the biomass stock

The mean calorific value of the wood was lowest for maple (19.41 kJ g^{-1} DM), intermediate for poplar (19.63 kJ g^{-1} DM) and willow (19.92 kJ g^{-1} DM), and highest for birch (21.30 kJ g^{-1} DM). Although the mean potential biomass production of birch was lower than the production of poplar and willow (Table 1), the total amount of energy stored in the biomass of birch was higher than that of willow, and was almost equal to the energy stored in the poplar trees (Table 4). As could be expected on base of the low biomass production and the low calorific value, maple had the lowest amount of energy stored in the biomass. The amount of usable energy depends on the conversion technique applied (Table 4). If both electrical and thermal power can be used, values between 18.6 and 61.7 GJ ha^{-1} $year^{-1}$ were found. If only the electrical energy can be utilized, usable energy values ranged from 3.7 to 26.2 GJ_e ha^{-1} $year^{-1}$, less than half of the total usable energy. As there was a large variation in biomass production all over the plantation at Zwijnaarde (Table 1), the total amount of usable electricity that can be produced was also calculated based on the results of the plot with the highest amount of energy stored in the biomass. This maximum biomass energy stock was found on one of the willow plots, as can be calculated from Table 1. Based on this best growing plot, the maximum amount of electricity that can be produced was 41.4 GJ_e ha^{-1} $year^{-1}$, while the total usable energy production was assessed at 97.4 GJ ha^{-1} $year^{-1}$ (Table 4).

Table 4
Energy stored in the biomass and usable energy produced from the biomass of four species of the short-rotation plantation in Zwijnaarde after four growing seasons

	Birch	Maple	Poplar	Willow	Max.
Biomass energy	69.7	23.2	70.9	67.3	111.9
Usable energy					
Co-burning					
Electricity	25.8	8.6	26.2	24.9	41.4
Heat	34.9	11.6	35.5	33.7	56.0
Total	60.7	20.2	61.7	58.6	97.4
Burning					
Electricity	11.2	3.7	11.3	10.8	17.9
Heat	48.1	16.0	48.9	46.4	77.2
Total	59.3	19.7	60.3	57.2	95.1
Gasification					
Electricity	18.8	6.3	19.2	18.2	30.2
Heat	37.0	12.3	37.6	35.7	59.3
Total	55.8	18.6	56.7	53.9	89.5

Three types of conversion processes are considered. Max. refers to the willow plot with the highest potential biomass production. All values are expressed in GJ ha^{-1} $year^{-1}$.

3.2. Energy efficiency

The energy input and energy efficiency of the three conversion processes are listed in Table 5. For all species and all conversion systems together, the energy efficiency was at least 1.4, and went up to 8.4. The efficiency of a combined heat and power system was more than double the efficiency of a system where only electricity is produced. Efficiencies were highest for birch, compared to the other species.

3.3. CO_2 emission reduction potential

In Fig. 1, the CO_2 emission reduction potential of 10,000 ha of SRF plantations of birch, maple, poplar or willow are presented. Emission reductions were highest

Table 5
Mean energy input (GJ ha^{-1} $year^{-1}$) for three types of conversion process during three stages of the energy production process; mean energy efficiency (dimensionless), calculated as the amount of usable energy produced to the energy input

	Birch	Maple	Poplar	Willow
Energy input (GJ ha^{-1} $year^{-1}$)				
(1) Establishment phase	3.436	1.461	3.759	3.536
(2) Transportation				
Co-burning	0.131	0.048	0.145	0.135
Burning	0.115	0.042	0.127	0.119
Gasification	0.065	0.024	0.072	0.068
(3) Conversion process				
Co-burning	4.882	1.626	4.966	4.712
Burning	3.487	1.161	3.547	3.366
Gasification	3.487	1.161	3.547	3.366
Total input				
Co-burning	8.449	3.134	8.869	8.383
Burning	7.039	2.664	7.433	7.021
Gasification	6.989	2.646	7.378	6.969
Energy efficiency (dimensionless)				
(1) Electricity production				
Co-burning	3.1	2.7	3.0	3.0
Burning	1.6	1.4	1.5	1.5
Gasification	2.7	2.4	2.6	2.6
(2) Heat production				
Co-burning	4.1	3.7	4.0	4.0
Burning	6.8	6.0	6.6	6.6
Gasification	5.3	4.7	5.1	5.1
(3) Combined heat and power				
Co-burning	7.2	6.4	7.0	7.0
Burning	8.4	7.4	8.1	8.1
Gasification	8.0	7.0	7.7	7.7

A 4-year rotation period and a plantation length of 20 years were assumed.

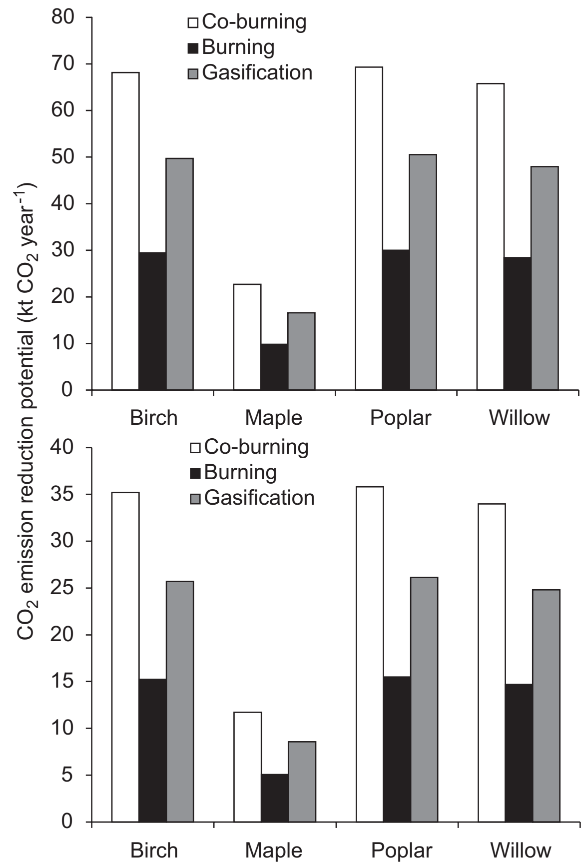

Fig. 1. CO_2 emission reduction potential (kt CO_2 $year^{-1}$) of 10,000 ha of birch, maple, poplar or willow SRF plantations compared to (a) the oldest coal plant of Belgium and (b) the most modern gas turbine.

when bioenergy production systems were compared to the oldest Belgian electricity plant. Depending on the conversion process chosen (co-burning, burning or gasification), using biomass instead of fossil fuel-based electricity could reduce CO_2 emissions with 9.8–69.3 kt CO_2 $year^{-1}$ (Fig. 1a). Reductions compared to a modern gas turbine ranged from 5.1 to 35.8 kt CO_2 $year^{-1}$ (Fig. 1b). Results were of course strongly dependent on the amount of energy stored in the biomass, which resulted from the combination of both the mean potential biomass production and the calorific value of the wood of a specific tree species.

4. Discussion

4.1. Energy production capacity of SRF in Flanders

Calorific values for different types of biomass reported in literature range from 13.50 to 24.00 kJ g^{-1} DM [18,27–36]. Values determined for birch, maple, poplar and willow in Zwijnaarde fell within this range. As stated above, the maximum area that can be expected to become available for the establishment of energy forests in Flanders amounts to 10,000 ha [8,26]. The maximum amount of electrical energy that can be provided by this area ranges from 23.9 GWh_e $year^{-1}$ for maple to 72.9 GWh_e $year^{-1}$ for poplar, if co-burning is considered. Assuming a mean energy need per household of 3300 kWh_e $year^{-1}$, the woody biomass of these 10,000 ha plantations can provide the electrical energy need of 7234 to 22,095 households per year. In Flanders, there are approximately 2.2 million households [26], which means that the number of households that can be provided by biomass electricity only accounts for 1.0% of all households in Flanders. The total electrical energy production in Flanders amounted to 46233 GWh_e in 2002 [37]. The highest result (co-burning of poplar wood) based on mean potential biomass production values of the plantation at Zwijnaarde showed that only 0.16% of this total electricity production could come from SRF biomass in Flanders. If the production result of the best (willow) plot of the plantation at Zwijnaarde was used as reference, the total number of households that could use biomass electricity was 34,857

per year, and SRF biomass could provide about 0.25% of the total electricity production in Flanders. As these last values are based on the result of one single plot, they are probably not as representative as the results based on the mean production values.

Although the total amount of energy produced is not that high, the efficiency of the bioenergy systems studied was always higher than 1, indicating that the systems can be considered as being energy efficient [16]. As the definition of the system boundaries are not always equal, it is difficult to compare energy ratios found here with values mentioned in literature [38,39]. Lettens et al. [23] however also concluded that low-input bioenergy crops are highly energy efficient. The high efficiency of birch compared to the other species could be attributed to the high calorific value of this species. From Table 5, it can also be concluded that research should be focused on the development of new combined heat and power systems, as these clearly have the highest energy efficiency.

The energy input related to the transportation phase was only minor compared to the input needed during the establishment phase and the conversion process itself (Table 5). However, if drying is done off-site, this transportation phase, which includes drying of the biomass, will require much more energy than was assumed here [5]. As the contributions of the establishment phase and the conversion process to the overall energy input were more or less comparable, enhancement of the energy efficiency of the bioenergy production process can be achieved by reducing the energy needed during the set-up of the plantation, as well as by fine-tuning existing or searching for new conversion processes that need less energy input.

In Flanders, there is a high population density of 430 residents km^{-2} [26]. This results in large claims on available land for all types of land use. As such, it can be expected that it will not be possible to establish large-scale SRF plantations in Flanders. Therefore, the combination of smaller SRF fields with small-scale local gasification installations seems to be the most promising option for using SRF biomass as energy source in Flanders. These installations are often of the combined heat and power type, and are as such more efficient than larger burning or co-burning installations from which only the electricity produced can be used (Table 5).

Biomass production results of birch in Zwijnaarde were lower than for poplar and willow (Table 1). However, birch was planted at a much lower density (6667 trees ha^{-1}) than those two last species (20,000 trees ha^{-1}), and it can be expected that a rotation length of more than 4 years will result in higher mean annual production values [11]. Moreover, the calorific value of birch is higher than the one of poplar and willow, which makes the production of electricity from birch wood more energy efficient. Combined with a higher water stress tolerance, birch is therefore an interesting species for SRF plantations in Flanders.

4.2. CO_2 emission reduction potential of SRF in Flanders

In 2000, the total CO_2 emissions in Flanders amounted to 76,264 kt CO_2 [37]. The maximum CO_2 emission reduction potential found here amounted to 69.3 kt $CO_2\,year^{-1}$, for 10,000 ha of poplar plantation (Fig. 1), or only 0.09% of the total annual CO_2 emissions. If calculations were based on the (willow) plot with the highest biomass production, the CO_2 emission reduction potential was 109.3 kt $CO_2\,year^{-1}$, or still only 0.14% of the total Flemish CO_2 emissions in 2000. From this, it can be concluded that the use of SRF energy will only be of minor significance in the view of reaching the Kyoto Protocol targets for Flanders. The critical parameters for this conclusion are the low biomass production levels found at our plantation, and the land scarcity in Flanders, which inhibits the extension of the area that will become available for SRF plantations. It can be doubted that the establishment of SRF plantations can create a large number of new jobs in Flanders, as was reported for other regions [22,40]. However, biomass plantations can have other benefits than only the reduction of CO_2 emissions and employment creation. Small-scale, extensively managed SRF plantations can prevent soil erosion [22] or improve the physical properties of the soil [4,41]; they can be established on marginal agricultural land or on contaminated sites unsuitable for food crops; they can have a recreational function or be a (temporary) habitat for many species, including birds [42,43], and thus serve as stepping stones or corridors between populations in protected areas [44,45]. Most probably, the highest benefits from SRF plantations in the densely populated and intensively managed region of Flanders will come from these 'additional' characteristics of SRF plantations.

5. Conclusions

Although energy production based on SRF biomass has a high efficiency, the total amount of electrical and thermal SRF energy that could be produced in Flanders is low. The CO_2 emission reduction potential of SRF plantations in Flanders seems to be very restricted as well. Main causes of these two phenomena are the land scarcity in this region as a result of the high population density, and the low biomass production values found at the plantation studied here. The most interesting option seems to be the combination of a combined heat and power installation with a relatively small SRF plantation in the close neighbourhood. As such, both electrical and thermal energy can be used, and transport costs are kept to a minimum. Other possible functions of SRF plantations are the prevention of soil erosion and the protection of soil water; moreover, SRF plantations can serve as (temporary) habitats for many species. However, to reach these objectives, it is important that SRF plantations are established on formerly intensively used agricultural land, and that as less herbicides and fertilizers as possible

(by preference: none of them) are applied. The tree species used should be indigenous, and suited to the site. Because of the high calorific value of birch wood and a higher water stress tolerance of this species compared to poplar and willow, birch could be a good choice for establishing SRF plantations on marginal agricultural soils in Flanders.

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